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TAPPAN RESERVOIR, HARRISON COUNTY, OHIO

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH
LABORATORY

PREPARED FOR
NATIONAL ENVIRONMENTAL RESEARCH CENTER

JUNE 1975

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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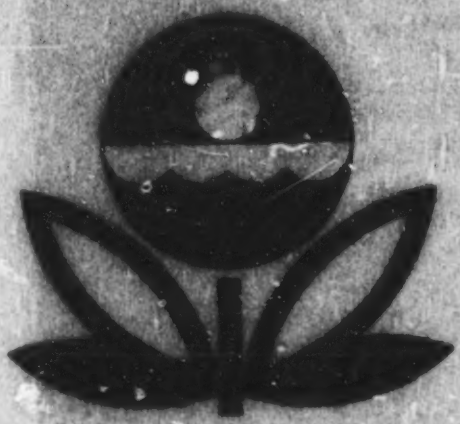

REPORT

ON

TAPPAN RESERVOIR

HARRISON COUNTY

OHIO

EPA REGION V

WORKING PAPER No. 412

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

An Associate Laboratory of the

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REPORT
ON
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WORKING PAPER No. 412

WITH THE COOPERATION OF THE

OHIO ENVIRONMENTAL PROTECTION AGENCY

AND THE

OHIO NATIONAL GUARD

JUNE, 1975

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Ohio Environmental Protection Agency for professional involvement, to the Ohio National Guard for conducting the tributary sampling phase of the Survey, and to those Ohio wastewater treatment plant operators who provided effluent samples and flow data.

Ned Williams, Director, and Tom Birch, Ken Carr, Larry Dietrick, Ron Havlice, Larry Korecko, Rod Mehlhop, Terry Wheeler, and John Youger, Ohio Environmental Protection Agency, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

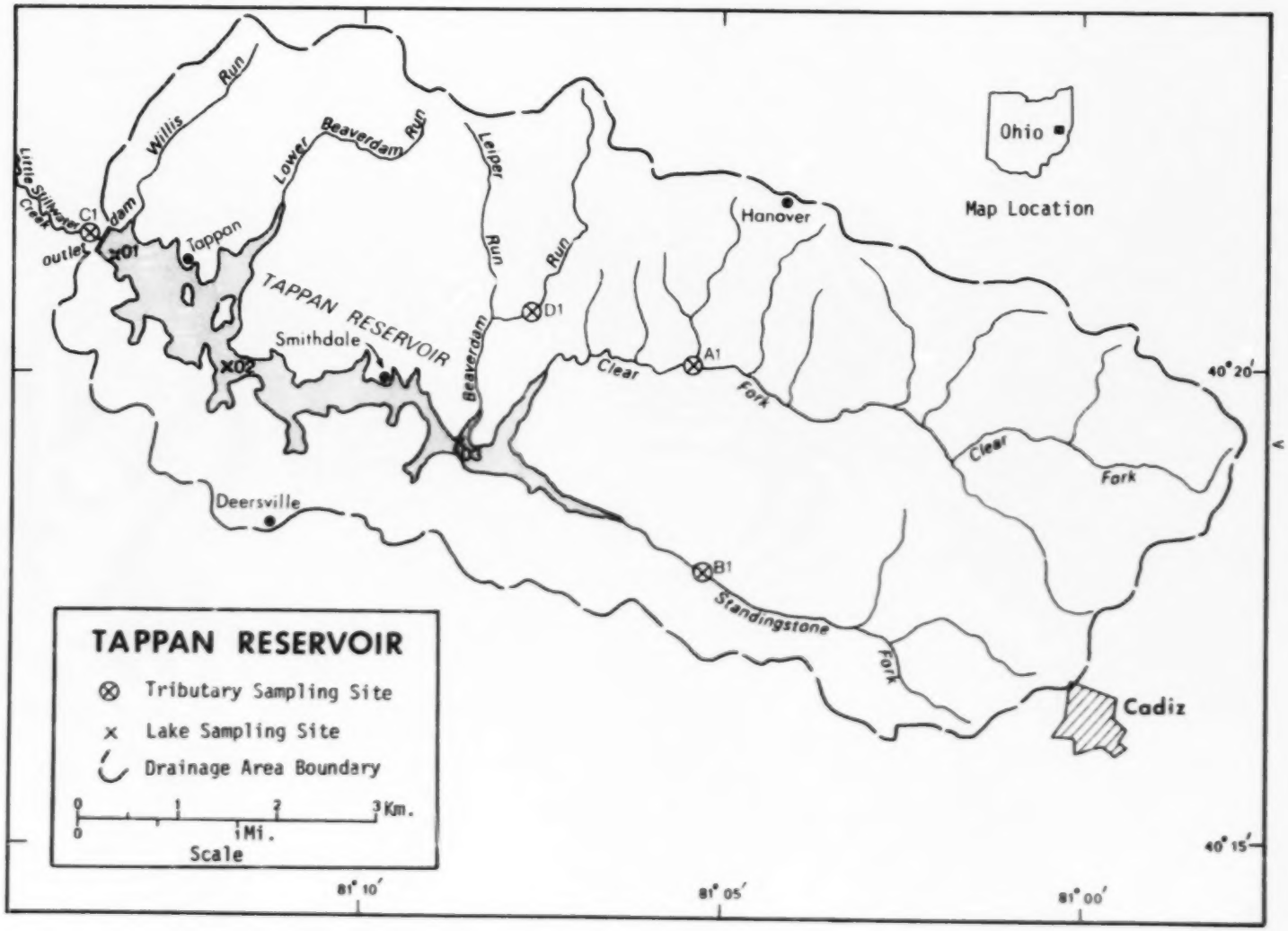
Major General Dana L. Stewart, then the Adjutant General of Ohio, and Project Officer Lt. Colonel Robert C. Timmons, who directed the volunteer efforts of the Ohio National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OHIO

LAKE NAME	COUNTY
Atwood	Carroll, Tuscarawas
Beach City	Stark, Tuscarawas
Berlin	Mahoning, Portage, Stark
Buckeye	Fairfield, Licking, Perry
Charles Mill	Ashland, Richland
Deer Creek	Fayette, Pickaway
Delaware	Delaware
Dillon	Muskingum
Grand Lake of St. Marys	Auglaize, Mercer
Grant	Brown
Holiday	Huron
Hoover	Delaware, Franklin
Indian	Logan
Loramie	Auglaize, Shelby
Mosquito Creek	Trumbull
O'Shaughnessy	Delaware
Pymatuning	Ashtabula, OH; Crawford, PA
Pleasant Hill	Ashland, Richland
Rocky Fork	Highland
Shawnee	Greene
Tappan	Harrison


Willis Run
Lower Beaverdam Run
Leiper Run
Beaverdam Run
Little Stillwater Creek
C1
dam
outlet
X01
Tappan
TAPPAN RESERVOIR
Smithdale
X02
D1
A1
Clear Fork
Clear Fork
Hanover
Ohio
Map Location
Deersville
B1
Standingstone Fork
Cadiz
40° 20′
40° 15′
81° 10′
81° 05′
81° 00′
TAPPAN RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
0 1 2 3 Km.
0 1 Mi.
Scale

TAPPAN RESERVOIR

STORET NO. 3934

I. CONCLUSIONS

A. Trophic Condition:

The Survey data indicate that Tappan Reservoir is eutrophic. It ranked sixth in overall trophic quality when the 20 Ohio lakes sampled in 1973 were compared using a combination of six parameters*. Two lakes had less and one had the same median total phosphorus, three had less median dissolved phosphorus, three had less median inorganic nitrogen, ten had less mean chlorophyll a, and six had greater mean Secchi disc transparency. Dissolved oxygen was depleted at the 6.4 meter depth at station 1 in July.

Survey limnologists reported surface algal blooms in July and October.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Tappan Reservoir was phosphorus limited when the sample was collected (04/21/73). This finding is substantiated by the lake data which show mean inorganic nitrogen to orthophosphorus ratios of 23 to 1 or greater at all sampling times.

C. Nutrient Controllability:

1. Point sources--The estimated total phosphorus contribution from septic tanks amounted to 1.3% of the total load. The present loading of 0.29 $g/m^2/yr$ is less than that proposed by Vollenweider

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* See Appendix A.

(Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11). Nonetheless, the reservoir is eutrophic, and phosphorus inputs should be minimized to the greatest practicable degree.

2. Non-point sources--About 99% of the total annual phosphorus input to Tappan Reservoir is attributable to non-point sources. Ungaged tributaries accounted for an estimated 44.3% of the total input. The other non-point sources are Clear Fork (23.1%), Standingstone Fork (20.2%), and Beaverdam Run (5.0%).

The phosphorus export rates of the sampled streams were quite low during the Survey sampling year (see page 10) and compare well with the mean export rate of the six Berlin Reservoir* tributaries (26 $g/km^2/yr$).

* Working Paper No. 395.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 9.51 kilometers^2.
2. Mean depth: 4.6 meters.
3. Maximum depth: >7.0 meters.
4. Volume: 43.746 x 10^6 m^3.
5. Mean hydraulic retention time: 241 days (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Clear Fork	55.7	0.6
Standingstone Fork	28.0	0.3
Beaverdam Run	9.8	0.1
Minor tributaries & immediate drainage -	81.1	1.0
Totals	174.6	2.0

2. Outlet -

Little Stillwater Creek	184.1**	2.1

C. Precipitation***:

1. Year of sampling: 106.2 centimeters.
2. Mean annual: 100.1 centimeters.

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† Table of metric equivalents--Appendix B.
†† Youger, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Tappan Reservoir was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and from two or more depths at each station (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 7.0 meters at station 1, 4.6 meters at station 2, and 1.8 meters at station 3.

The lake sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR TAPPAN LAKE
STORET CODE 3934

	1ST SAMPLING (4/21/73) 3 SITES			2ND SAMPLING (7/30/73) 3 SITES			3RD SAMPLING (10/ 6/73) 3 SITES		
PARAMETER	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	10.0 - 16.0	12.5	11.7	16.4 - 26.5	24.1	24.9	19.0 - 19.9	19.5	19.6
DISS OXY (MG/L)	9.8 - 93.0	25.5	12.9	0.0 - 8.3	5.4	6.2	3.6 - 7.4	6.1	6.4
CNDCTVY (MCROMO)	520. - 775.	599.	570.	551. - 850.	699.	680.	613. - 716.	645.	626.
PH (STAND UNITS)	8.2 - 9.0	8.7	8.9	7.3 - 9.1	8.2	8.4	7.2 - 8.2	7.7	7.5
TOT ALK (MG/L)	75. - 100.	81.	76.	65. - 120.	81.	77.	62. - 82.	70.	71.
TOT P (MG/L)	0.017 - 0.028	0.022	0.023	0.034 - 0.138	0.068	0.051	0.056 - 0.112	0.076	0.067
ORTHO P (MG/L)	0.005 - 0.009	0.006	0.006	0.002 - 0.021	0.010	0.008	0.007 - 0.038	0.014	0.010
NO2+NO3 (MG/L)	0.200 - 0.330	0.281	0.290	0.050 - 0.080	0.064	0.060	0.020 - 0.040	0.030	0.030
AMMONIA (MG/L)	0.030 - 0.090	0.073	0.080	0.060 - 0.990	0.173	0.070	0.060 - 0.740	0.289	0.240
KJEL N (MG/L)	0.300 - 0.900	0.622	0.600	0.700 - 1.600	1.067	1.000	0.900 - 1.700	1.229	1.180
INORG N (MG/L)	0.280 - 0.420	0.354	0.350	0.110 - 1.070	0.238	0.140	0.100 - 0.770	0.319	0.270
TOTAL N (MG/L)	0.620 - 1.100	0.903	0.910	0.750 - 1.680	1.131	1.060	0.930 - 1.730	1.259	1.130
CHLRPYL A (UG/L)	21.3 - 28.3	25.5	27.0	27.4 - 97.0	53.2	35.2	19.9 - 47.4	34.4	35.9
SECCHI (METERS)	0.9 - 1.0	0.9	0.9	0.4 - 1.0	0.7	0.8	0.5 - 1.2	0.9	1.0

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/21/73	1. Oscillatoria sp.	8,327
	2. Flagellates	2,988
	3. Synedra sp.	2,743
	4. Cryptomonas sp.	1,225
	5. Centric diatoms	686
	Other genera	635
	Total	16,604
07/30/73	1. Oscillatoria sp.	217,182
	2. Raphidiopsis sp.	107,567
	3. Stephanodiscus sp.	589
	4. Synedra sp.	359
	5. Anabaena sp.	154
	Other genera	436
	Total	326,287
10/06/73	1. Oscillatoria sp.	16,750
	2. Raphidiopsis sp.	8,878
	3. Merismopedia sp.	3,374
	4. Nitzschia sp.	3,314
	5. Flagellates	2,367
	Other genera	6,037
	Total	40,720

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
04/21/73	01	28.3
	02	27.0
	03	21.3
07/30/73	01	27.4
	02	25.2
	03	97.0
10/06/73	01	35.9
	02	19.9
	03	47.4

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.012	0.360	0.5
0.050 P	0.062	0.360	6.9
0.050 P + 1.0 N	0.062	1.360	13.1
1.0 N	0.012	1.360	0.5

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Tappan Reservoir was moderate at the time the sample was collected (04/21/73). The addition of phosphorus alone produced a significant increase in yield, whereas no such increase was seen with the addition of nitrogen alone. Therefore, phosphorus limitation is indicated.

The lake data substantiate this conclusion. At all sampling times, the mean inorganic nitrogen to orthophosphorus ratios were 23 to 1 or greater.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Ohio National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in May, 1973, and was completed in April, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Ohio District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in $kg/km^2/year$, at stations A-1, B-1, and D-1 and multiplying the means by the ZZ area in km^2.

There are no known municipal waste treatment plants impacting Tappan Reservoir.

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* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal - None

2. Known municipal - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Clear Fork	630	23.1
Standingstone Fork	550	20.1
Beaverdam Run	135	4.9
b. Minor tributaries & immediate drainage (non-point load) -	1,215	44.5
c. Known municipal - None	-	-
d. Septic tanks* -	35	1.3
e. Known industrial - None	-	-
f. Direct precipitation** -	165	6.1
Total	2,730	100.0

2. Outputs -

Lake outlet - Little Stillwater Creek	5,550

3. Net annual P loss - 2,820 kg.

* Estimate based on 112 seasonal lakeshore dwellings and two parks; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Clear Fork	23,430	26.5
Standingstone Fork	12,220	13.8
Beaverdam Run	4,775	5.4
b. Minor tributaries & immediate drainage (non-point load) -	36,335	41.3
c. Known municipal - None	-	-
d. Septic tanks* -	1,265	1.4
e. Known industrial - None	-	-
f. Direct precipitation** -	10,265	11.6
Total	88,290	100.0

2. Outputs -

Lake outlet - Little Stillwater Creek	120,520

3. Net annual N loss - 32,230 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Clear Fork	11	421
Standingstone Fork	20	436
Beaverdam Run	14	487

* Estimate based on 112 seasonal lakeshore dwellings and two parks; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loadings:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.29	loss*	9.3	loss*

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Tappan Reservoir:

"Dangerous" (eutrophic loading)	0.52
"Permissible" (oligotrophic loading)	0.26

* There was an apparent loss of nutrients during the sampling year. This may have been due to nitrogen fixation in the lake, solubilization of previously sedimented nutrients, recharge with nutrient-rich ground water, unknown and unsampled point sources discharging directly to the lake, or underestimation of the nutrient loads from ungaged tributaries. By trimming the August and September total phosphorus concentrations at the outlet, which appear to be higher than normal, the outlet phosphorus loading is reduced to 2,330 kg/yr and a net accumulation of 1,080 kg/yr is seen. Doing the same for total nitrogen gives outlet N of 85,250 kg/yr and net accumulation of 28,935 kg/yr.

V. LITERATUR REVIEWED

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Youger, John, 1975. Personal communication (lake morphometry) OH Env. Prot. Agency, Columbus.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3926	ATWOOD RESERVOIR	491
2	3921	MOSQUITO CREEK RESERVOIR	483
3	3924	PLEASANT HILL LAKE	431
4	3929	BERLIN RESERVOIR	429
5	3914	HOOVER RESERVOIR	392
6	3934	TAPPAN LAKE	381
7	3927	LAKE SAINT MARYS	297
8	3932	ROCKY FORK LAKE	292
9	3906	DEER CREEK RESERVOIR	290
10	3901	BEACH CITY RESERVOIR	277
11	3915	INDIAN LAKE	266
12	3907	DELAWARE RESERVOIR	263
13	3912	GRANT LAKE	261
14	3933	SHAWNEE LAKE	249
15	3930	HOLIDAY LAKE	220
16	3905	CHARLES MILL RESERVOIR	216
17	3902	BUCKEYE LAKE	207
18	3908	DILLION RESERVOIR	206
19	3917	LORAMIE LAKE	178
20	3931	O'SHAUGNESSY RESERVOIR	173

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SOO-MEAN SEC	MEAN CHLORA	1S-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3901	BEACH CITY RESERVOIR	37 (7)	21 (4)	11 (2)	84 (16)	82 (15)	42 (8)	277
3902	BUCKEYE LAKE	11 (2)	76 (14)	5 (1)	0 (0)	89 (17)	26 (5)	207
3905	CHARLES MILL RESERVOIR	26 (5)	63 (12)	37 (7)	21 (4)	11 (0)	58 (11)	216
3906	DEER CREEK RESERVOIR	53 (10)	5 (1)	63 (12)	95 (18)	63 (12)	11 (2)	290
3907	DELAWARE RESERVOIR	58 (11)	16 (3)	32 (6)	89 (17)	47 (9)	21 (4)	263
3908	DILLION RESERVOIR	16 (3)	32 (6)	42 (8)	58 (11)	53 (10)	5 (1)	206
3912	GRANT LAKE	47 (9)	58 (11)	16 (3)	32 (6)	74 (14)	34 (6)	261
3914	HOOVER RESERVOIR	87 (16)	26 (5)	89 (17)	79 (15)	32 (6)	79 (15)	392
3915	INDIAN LAKE	42 (8)	76 (14)	21 (4)	16 (3)	58 (11)	53 (10)	266
3917	LORAMIE LAKE	5 (1)	37 (7)	0 (0)	5 (1)	97 (18)	34 (6)	178
3921	MOSQUITO CREEK RESERVOIR	74 (14)	100 (19)	82 (15)	53 (10)	82 (15)	92 (17)	483
3924	PLEASANT HILL LAKE	95 (18)	68 (13)	100 (19)	63 (12)	39 (7)	66 (12)	431
3927	LAKE SAINT MARYS	21 (4)	95 (18)	26 (5)	11 (2)	97 (18)	47 (9)	297
3928	ATWOOD RESERVOIR	100 (19)	89 (17)	95 (18)	68 (13)	39 (7)	100 (19)	491
3929	BERLIN RESERVOIR	79 (15)	42 (8)	74 (14)	74 (14)	68 (13)	92 (17)	429
3930	HOLIDAY LAKE	32 (6)	53 (10)	82 (15)	26 (5)	11 (0)	16 (3)	220
3931	O'SHAUGNESSY RESERVOIR	0 (0)	0 (0)	47 (9)	100 (19)	26 (5)	0 (0)	173
3932	ROCKY FORK LAKE	68 (13)	47 (9)	58 (11)	42 (8)	11 (0)	66 (12)	292
3933	SHAWNEE LAKE	63 (12)	11 (2)	53 (10)	37 (7)	11 (0)	74 (14)	249
3934	TAPPAN LAKE	87 (16)	84 (16)	68 (13)	47 (9)	11 (0)	84 (16)	381

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
3901	BEACH CITY RESERVOIR	0.122	1.490	489.000	10.867	11.600	0.015
3902	BUCKEYE LAKE	0.179	0.380	490.000	186.567	9.600	0.020
3905	CHARLES MILL RESERVOIR	0.127	0.465	482.555	67.144	15.000	0.011
3906	DEER CREEK RESERVOIR	0.098	2.980	470.125	9.887	13.900	0.036
3907	DELAWARE RESERVOIR	0.086	2.340	484.111	10.856	14.500	0.024
3908	DILLION RESERVOIR	0.163	1.590	481.250	27.400	14.300	0.037
3912	GRANT LAKE	0.113	0.570	486.333	40.533	12.200	0.019
3914	HOOVER RESERVOIR	0.040	1.640	462.750	13.017	14.800	0.008
3915	INDIAN LAKE	0.120	0.380	485.222	76.855	14.200	0.012
3917	LORAMIE LAKE	0.185	1.380	494.000	104.100	8.200	0.019
3921	MOSQUITO CREEK RESERVOIR	0.058	0.150	465.333	36.267	11.600	0.006
3924	PLEASANT HILL LAKE	0.036	0.455	456.833	22.850	14.700	0.010
3927	LAKE SAINT MARYS	0.148	0.200	484.167	79.150	8.200	0.014
3928	ATWOOD RESERVOIR	0.031	0.205	462.000	16.442	14.700	0.005
3929	BERLIN RESERVOIR	0.042	0.400	465.435	15.496	13.600	0.006
3930	HOLIDAY LAKE	0.125	0.575	465.333	55.350	15.000	0.034
3931	O'SHAUGNESSY RESERVOIR	0.208	3.070	479.333	5.522	14.900	0.159
3932	ROCKY FORK LAKE	0.067	0.790	473.000	38.022	15.000	0.010
3933	SHAWNEE LAKE	0.069	2.380	474.333	39.567	15.000	0.009
3934	TAPPAN LAKE	0.040	0.280	466.111	37.711	15.000	0.007

APPENDIX B

CONVERSIONS FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR OHIO 1/27/75

LAKE CODE 3934 TAPPAN RESERVOIR

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 184.1

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3934A1	55.7	0.99	1.19	1.39	1.10	0.65	0.37	0.23	0.18	0.12	0.10	0.27	0.57	0.59
3934B1	28.0	0.48	0.62	0.71	0.57	0.34	0.18	0.12	0.08	0.06	0.05	0.13	0.28	0.30
3934C1	184.1	2.92	2.97	3.99	4.08	2.63	1.56	0.96	0.54	0.28	0.93	2.21	1.87	2.07
3934D1	9.8	0.17	0.22	0.25	0.20	0.12	0.06	0.04	0.03	0.02	0.02	0.04	0.10	0.10
3934Z2	90.6	1.61	1.93	2.21	1.78	1.05	0.59	0.37	0.28	0.21	0.18	0.45	0.93	0.96

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 184.1
SUM OF SUB-DRAINAGE AREAS = 184.1

TOTAL FLOW IN = 23.64
TOTAL FLOW OUT = 24.95

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3934A1	5	73	1.70	5	0.16				
	6	73	0.54	3	0.91				
	7	73	0.15	7	0.25				
	8	73	0.05	11	0.12				
	9	73	0.02	9	0.01				
	10	73	0.05	14	0.08				
	11	73	0.26	11	0.03				
	12	73	0.51	8	0.14				
	1	74	1.08	13	0.65				
	2	74	0.57	9	0.37	24	0.74		
	3	74	1.13	9	1.27	23	1.10		
	4	74	1.22	13	1.16				
3934B1	5	73	0.91	5	0.08				
	6	73	0.27	3	0.45				
	7	73	0.08	7	0.12				
	8	73	0.03	11	0.06				
	9	73	0.01	9	0.05				
	10	73	0.02	14	0.04				
	11	73	0.13	11	0.01				
	12	73	0.26	8	0.07				
	1	74	0.51	13	0.34				
	2	74	0.31	9	0.18	24	0.37		
	3	74	0.57	9	0.65	23	0.57		
	4	74	0.62	13	0.59				

TRIBUTARY FLOW INFORMATION FOR OHIO 1/27/75

LAKE CODE 3934 TAPPAN RESERVOIR

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3934C1	5	73	4.67	5	2.46				
	6	73	1.87	3	5.30				
	7	73	0.24	7	0.31				
	8	73	0.12	11	0.07				
	9	73	0.07	9	0.06				
	10	73	0.07	14	0.06				
	11	73	3.17	11	0.08				
	12	73	2.97	8	6.14				
	1	74	4.33	13	0.06				
	2	74	1.67	9	0.31	24	0.06		
	3	74	0.08	9	0.04	23	0.03		
	4	74	4.13	13	7.93				
393401	5	73	0.31	5	0.03				
	6	73	0.09	3	0.16				
	7	73	0.03	7	0.04				
	8	73	0.01	11	0.02				
	9	73	0.00	9	0.00				
	10	73	0.01	14	0.01				
	11	73	0.04	11	0.01				
	12	73	0.09	8	0.02				
	1	74	0.18	13	0.11				
	2	74	0.10	9	0.07	24	0.13		
	3	74	0.21	9	0.22	23	0.19		
	4	74	0.22	13	0.20				
393422	5	73	2.75						
	6	73	0.88						
	7	73	0.24						
	8	73	0.08						
	9	73	0.03						
	10	73	0.09						
	11	73	0.42						
	12	73	0.88						
	1	74	1.73						
	2	74	0.93						
	3	74	1.78						
	4	74	1.95						

2/

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/01/27

393401
40 21 20.0 081 13 25.0
TAPPAN LAKE
39067 OHIO

11EPALES
3

2111202
0027 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/21	10 20	0000	14.5		38	540	9.00	75	0.080	0.900	0.200	0.005
	10 20	0006	12.6	14.2		520	9.00	75	0.080	0.600	0.250	0.005
	10 20	0015	11.4	12.6		540	8.90	75	0.090	0.600	0.280	0.006
	10 20	0023	10.0	9.8		540	8.40	76	0.090	0.600	0.310	0.005
73/07/30	13 50	0000	25.0		39	660	8.80	76	0.070	1.300	0.070	0.008
	13 50	0005	24.8	7.8		661	8.60	75	0.060	0.800	0.050	0.010
	13 50	0015	24.4	4.7		662	7.70	81	0.060	0.700	0.050	0.021
	13 50	0021	16.4	0.0		551	7.30	120	0.990	1.600	0.080	0.007
73/10/06	10 20	0000	19.6	6.0	39	615	7.90	72	0.300	1.100	0.030	0.009
	10 20	0015	19.6	5.6		614	7.50	73	0.370	1.100	0.020	0.010
	10 20	0023	19.0	3.6		613	7.20	82	0.740	1.700	0.030	0.038

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/21	10 20	0000	0.020	24.3
	10 20	0006	0.028	
	10 20	0015	0.023	
	10 20	0023	0.024	
73/07/30	13 50	0000	0.034	27.4
	13 50	0005	0.034	
	13 50	0015	0.051	
	13 50	0021	0.138	
73/10/06	10 20	0000	0.056	35.9
	10 20	0015	0.057	
	10 20	0023	0.112	

STORET RETRIEVAL DATE 75/01/27

333402
40 20 10.0 081 11 49.0
TAPPAN LAKE
39067 OHIO

11EPALES
3

2111202
0019 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/21	10 50	0000	14.6		36	580	8.90	78	0.070	0.700	0.240	0.006
	10 50	0006	11.5	13.3		570	8.90	75	0.090	0.600	0.290	0.007
	10 50	0015	10.6	10.0		580	8.50	79	0.090	0.600	0.330	0.006
73/07/30	14 30	0000	26.0		33	708	7.50	77	0.070	1.000	0.060	0.002
	14 30	0005	24.9	8.3		680	8.60	78	0.060	0.900	0.060	0.005
	14 30	0015	24.4	3.6		685	8.10	85	0.090	0.900	0.050	0.007
73/10/06	09 45	0000	19.9	6.4	48	626	7.30	71	0.240	1.100	0.030	0.007
	09 45	0015	19.8	6.4		626	7.30	70	0.240	0.900	0.030	0.014

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/21	10 50	0000	0.018	27.0
	10 50	0006	0.021	
	10 50	0015	0.026	
73/07/30	14 30	0000	0.034	35.2
	14 30	0005	0.040	
	14 30	0015	0.055	
73/10/06	09 45	0000	0.060	19.9
	09 45	0015	0.067	

STORET RETRIEVAL DATE 75/01/27

393403
40 19 26.0 081 08 43.0
TAPPAN LAKE
39067 OHIO

11EPALES
3

2111202
0010 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/21	11 10	0000	16.0		36	775	8.20	100	0.030	0.300	0.320	0.009
	11 10	0006	11.7	93.0		750	8.20	97	0.040	0.700	0.310	0.005
73/07/30	14 55	0000	26.5		16	850	9.10	74	0.070	1.300	0.080	0.015
	14 55	0005	24.9	7.9		830	8.40	65	0.090	1.100	0.080	0.013
73/10/06	10 45	0000	19.4	7.4	20	708	8.20	62	0.060	1.400	0.040	0.011
	10 45	0005	19.2	7.0		716	8.20	63	0.070	1.300	0.030	0.010

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/21	11 10	0000	0.017	21.3
	11 10	0006	0.023	
73/07/30	14 55	0000	0.108	97.0
	14 55	0005	0.122	
73/10/06	10 45	0000	0.103	47.4
	10 45	0005	0.075	

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/02/03

3934A1
40 20 14.0 081 05 14.0
CLEAR FORK
39057 7.5 JEWETT
T/TAPPEN RESERVOIR
2NDRY RD BRDG 2.5 MI SSW OF HANOVER
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	11 15		0.460	0.380	0.018	0.005K	0.020
73/06/03	09 40		0.010K	0.290	0.006	0.006	0.025
73/07/07	11 00		0.154	3.000	0.160	0.017	0.020
73/08/11	10 14			0.560	0.056	0.009	0.100
73/09/04	09 20		0.015	0.595	0.058	0.009	0.040
73/10/14	10 15		0.018	1.850	0.052	0.011	0.075
73/11/11	11 10		0.176	0.500	0.044	0.012	0.020
73/12/08			0.552	0.300	0.022	0.012	0.035
74/01/13	11 20		0.890	0.200	0.068	0.005K	0.015
74/02/09	11 30		0.792	0.100	0.007	0.005K	0.010
74/02/24	11 30		1.920	0.300	0.020	0.005K	0.035
74/03/09	13 00		0.410	0.100	0.015	0.005K	0.050
74/03/23	13 40		0.580	0.300	0.015	0.010	0.025
74/04/13	11 30		0.552	0.300	0.010	0.005K	0.005K

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/03

393481
40 17 55.0 081 05 10.0
STANDINGSTONE FORK
39 7.5 JEWETT
T/TAPPEN RESERVOIR
2NDRY RD BRDG 1 MI N OF ASBURY CHAPEL
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	09	45	0.670	0.460	0.018	0.008	0.030
73/06/03	08	45	0.010K	0.330	0.005K	0.007	0.035
73/07/07	09	45	0.189	1.600	0.105	0.021	0.045
73/08/11	09	20	0.105	1.890	0.068	0.040	0.090
73/09/09	08	30	0.046	1.050	0.150	0.023	0.070
73/10/14	09	20	0.230	1.750	0.058	0.062	0.140
73/11/11	10	20	0.208	0.500	0.046	0.056	0.153
73/12/08			0.440	0.200	0.040	0.024	0.065
74/01/13	09	45	0.830	0.200	0.036	0.010	0.045
74/02/09	09	25	0.890	0.200	0.015	0.010	0.025
74/02/24	11	15	1.500	0.300	0.015	0.005	0.030
74/03/09	11	30	0.330	0.300	0.015	0.010	0.045
74/03/23	16	55	0.490	0.500	0.020	0.015	0.035
74/04/13	11	15	0.490	0.300	0.010	0.010	0.020

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/03

3934C1
40 21 20.0 084 13 45.0
LITTLE STILLWATER CREEK
39 7.5 DEERSFIELD
O/TAPPEN RESERVOIR
2NDRY RD BRDG 0.1 MI BELO DAM
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	10	20	0.027	2.300	0.044	0.005K	0.040
73/06/03	09	10	0.010K	1.400	0.130	0.013	0.030
73/07/07	10	00	0.019	2.800	0.840	0.023	0.025
73/08/11	09	43	0.033	2.000		0.069	0.345
73/09/09	08	45	0.094	3.000	1.600	0.110	0.400
73/10/14	09	30	0.022	3.350	1.890		
73/11/11	10	40	0.168	0.750	0.148	0.016	0.050
73/12/08			0.124	0.600	0.128	0.012	0.050
74/01/13	10	00	0.440	0.600	0.092	0.010	0.040
74/02/09	10	05	0.410	0.400	0.025	0.005K	0.015
74/02/24	12	00	0.400	0.500	0.010	0.005K	0.050
74/03/09	12	30	0.420	0.500	0.007	0.005K	0.065
74/03/23	17	10	0.276	0.900	0.020	0.010	0.020
74/04/13	12	00	0.012	0.700	0.005	0.005	0.007

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/03

3+3401
40 20 47.0 081 07 36.0
BEAVERDAM RUN
39 7.5 DEERSFIELD
T/TAPPEN RESERVOIR
2NORY RD 4MDG 0.1 MI SE OF MT HOPE CHURC
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	11 00		0.730	0.290	0.018	0.006	0.030
73/06/03	09 30		0.765	0.950	0.135	0.016	0.025
73/07/07	10 20		0.200	2.200	0.094	0.015	0.035
73/08/11	10 05		0.280	0.950	0.088	0.016	0.080
73/09/05	09 00		0.115	1.500	0.260	0.020	0.095
73/10/14	10 00		0.015	1.800	0.067	0.023	0.100
73/11/11	11 05		0.112	0.350	0.032	0.015	0.035
73/12/04			0.400	0.200	0.028	0.012	0.030
74/01/13	10 30		1.010	0.200	0.032	0.005K	0.025
74/02/04	10 20		1.120	0.100	0.010	0.005	0.020
74/02/24	11 45		0.940	0.400	0.010	0.005K	0.025
74/03/04	12 45		0.720	0.200	0.010	0.005K	0.050
74/03/23	17 25		0.800	0.100	0.010	0.005	0.025
74/04/13	11 45		0.820	0.500	0.015	0.005	0.005

K VALUE KNOWN TO BE
LESS THAN INDICATED